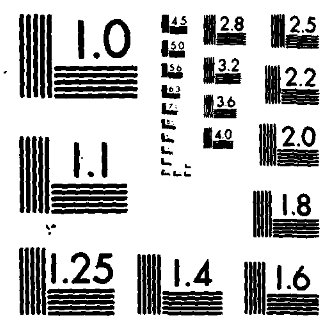
AD-A092 204 DEFENCE AND CIVIL INST OF ENVIRONMENTAL MEDICINE DOW--ETC F/G 6/11
EVALUATION OF THE SCOTT AVIOX EMERGENCY OXYGEN SYSTEM DURING A --ETC(U)
SEP 80 A G HYNES

UNCLASSIFIED DCIEM-80-R-42 NL

1 of 1

END
DATE
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SEPTEMBER 1980

DCIEM ~~Report No.~~ 80-R-42

EVALUATION OF THE SCOTT AVIOX EMERGENCY OXYGEN SYSTEM DURING A RAPID DECOMPRESSION TO 25,000 FEET

A.G. Hynes

Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West, P.O. Box 2000
Downsview, Ontario M3M 3B9

DEPARTMENT OF NATIONAL DEFENCE - CANADA

TABLE OF CONTENTS

Abstract 1

Introduction 2

Methods 3

Results 4

Discussion 5

Conclusion 6

ABSTRACT

With the acquisition of the new Long Range Patrol Aircraft (LRPA) the CP-140 Aurora, the Canadian Forces will also see the introduction of a new emergency supplemental oxygen system. ~~This new system~~ is the Scott Aviox Single Pak, which utilizes solid state oxygen generators composed of sodium chlorate for oxygen production. The sodium chlorate is degraded by an exothermic chemical reaction that liberates a continuous flow of oxygen. As this method of oxygen production was novel to the Canadian Forces, a series of evaluations was undertaken to determine the overall reliability and oxygen output of the system under static conditions. Results of these tests proved favourable; therefore, to fully evaluate this system's performance, it was subjected to the next stage which consisted of use by human subjects under hypobaric conditions.

During this experiment five male subjects were individually exposed to hypobaric conditions. Each was subjected to a rapid decompression from 8,000 to 25,000 feet. Upon reaching the final altitude the Aviox unit was removed from its retaining bracket and utilized as a source of supplemental oxygen. The subjects then descended to 22,000 feet where they were maintained for 15 minutes breathing oxygen from the Aviox unit. During this time period, observations were conducted to determine the degree of difficulty associated with removing the Aviox from its bracket, donning and activating the oxygen flow. Arterial oxygen saturation levels were also monitored throughout the experiment to determine the degree of protection this system afforded against hypoxia.

Experimental results and observations indicated that the subjects had very little difficulty in placing the system into use after the decompression. Recorded oxygen saturation levels show that this system provided more than the required degree of hypoxia protection at the experimental altitudes.

EVALUATION OF THE SCOTT AVIOX EMERGENCY OXYGEN SYSTEM DURING A RAPID DECOMPRESSION TO 25,000 FEET

INTRODUCTION

In the Canadian Forces new Long Range Patrol Aircraft (LRPA), the CP-140 Aurora, emergency supplemental oxygen will be supplied to crew members by the Scott Aviox Single Pak System. This system differs from conventional supplies of liquid or gaseous oxygen in that it is a solid state system which utilizes a chemical composition that degrades for oxygen production.

Since this system is new within the CF; a series of experiments have been carried out to establish its reliability and oxygen production capability. These have included toxicology studies and static evaluations of performance of the system in hot and cold environments at ground level. This paper is concerned with experimental testing with human subjects under simulated hypobaric conditions which may be encountered in operational use with the LRPA. The purpose of these tests was to determine the degree of protection the Aviox system afforded against hypoxia and to determine the degree of difficulty of donning and initiating procedures experienced by the subjects.

In the aviation field, the physiological limitations of man operating at altitude, requires an oxygen concentration greater than that of inspired air at sea level. At sea level, inspired air has an atmospheric pressure of 760 mmHg and contains 20.95% oxygen. Dalton's *Law of Partial Pressure* states that the pressure exerted by each component of a gas mixture is equal to the sum of the separate pressures which each gas would exert if it alone occupied the whole volume. Therefore, at sea level oxygen has a partial pressure of 149 mmHg, but when inspired, the carbon dioxide that is present assumes a partial pressure of 40 mmHg, thus reducing to 109 mmHg the pressure of oxygen in the alveoli of the lungs. (PA02)

This alveolar P02 of 109 mmHg is the driving pressure for diffusion of oxygen from the alveoli to the red blood cell where it combines with hemoglobin. From here the oxygen in the blood (in the form of oxy-hemoglobin) is delivered throughout the body to the cell level, where it is utilized for metabolism. At sea level with an alveolar pressure of 109 mmHg, the oxygen saturation of arterial blood is between 97 and 98%. Increases in altitude with a resulting reduction in barometric pressure, result in a lower partial pressure of oxygen being available for diffusion into the blood. This causes a reduction in arterial oxygen saturation levels. For example, when air is breathed at 22,000 feet, the arterial oxygen saturation level would be as low as 55%. This reduced oxygen saturation is insufficient to maintain normal cellular metabolism and leads to serious physiological impairment. This condition is known as hypoxia. With further decreases in actual oxygen saturation, symptoms become more severe leading to loss of consciousness and, eventually, death.

This reduced oxygen saturation is insufficient to maintain normal cellular metabolism and leads to serious physiological impairment. This condition is known as hypoxia. With further decreases in actual oxygen saturation, symptoms become more severe leading to loss of

consciousness and, eventually, death.

To prevent this fall in arterial oxygen saturation, the oxygen concentration in the inspired air must be raised. In doing so, the volume of oxygen is increased and according to Dalton's Law, also the partial pressure of oxygen. By increasing the oxygen concentration in proportionate quantities, an alveolar pressure of 109 mmHg can be maintained, ensuring the equivalent of sea level saturations of the blood at altitudes up to 33,000 feet. (At this altitude, breathing 100% oxygen would provide an arterial oxygen saturation of 95 - 100%.)

METHODS

Five healthy, medically screened adult male volunteers were selected for this experiment. All received instruction on the Scott Aviox Single Pak System (SCT-802501-15 and replacement generators SCT-802111-00) which included donning and initiating procedures. To ensure that the subjects were relatively familiar with the system, the instruction consisted of one demonstration with each subject performing the donning and initiating procedures twice at ground level.

The Aviox was installed in the DCIEM hypobaric chamber in a wall bracket similar to that which will be employed in the LRPA. In order to prevent decompression sickness, each subject entered the chamber and began breathing 100% oxygen for 30 minutes prior to the decompression. At the end of 30 minutes, the chamber altitude was raised to 8,000 feet to simulate the cabin pressurization of the LRPA. At 8,000 feet the subject removed his oxygen mask and a rapid decompression to 25,000 feet was achieved within 15 seconds. It must be pointed out that this altitude is lower than the maximum operational ceiling of the LRPA but was selected as it still forms part of the upper altitude range for normal operations. Safety considerations for the subjects were the main factors in determining this final altitude. Subjects were continuously monitored with an electrocardiograph (for evidence of arrythmias) and arterial oxygen saturation (using a Hewlett Packard Oximeter Model 47201A) throughout the experiment.

At the end of decompression, each subject stood and walked 15 paces in place before removing the Aviox from its bracket and placing it into use. This was done to simulate the furthest distance that aircrew might be required to walk to one of the systems after a real decompression incident. The time from start of decompression until the Aviox System was used was recorded by an outside observer. Thirty seconds after the decompression was initiated the chamber altitude was allowed to descend at a rate of 5,000 feet per minute. Upon attaining 22,000 feet, the altitude was maintained constant for an additional 15 minutes. (This level was deliberately chosen to follow as closely as possible the emergency flight conditions in a decompressed cabin. Continued flight in an unpressurized aircraft above this altitude would increase the severity of hypoxia and incidence of decompression sickness.)

During such an event, crew members may be required to perform some physical exertion to check aircraft systems and possibly render first-aid or assistance to other injured crew members, therefore, the

subject was required to walk 15 paces in place every minute at 22,000 ft. (Oxygen saturation levels are dependant on a variety of factors one of which is physiological stress, therefore, a level of exercise greater than that associated with the seated, resting person was introduced.) At the end of 15 minutes at 22,000 feet, the subject was returned to the chamber oxygen supply and descended to ground level.

RESULTS

Table 1 shows the recorded arterial oxygen saturation levels observed in subjects throughout the experiment. The initial drops in saturation levels were observed before the subjects were using the Scott Aviox and were related to the drop of oxygen tension in the inspired air that was encountered during the decompression and at the final altitude before use of the oxygen system.

TABLE 1

OXYGEN SATURATION OF SUBJECTS USING THE SCOTT AVIOX EMERGENCY OXYGEN SYSTEM DURING EXPOSURE TO ALTITUDE

	S U B J E C T S					$\bar{X}$ ± Standard Deviation
	1	2	3	4	5	
% Oxygen Saturation Before Start of Rapid Decompression	99	99	99	100	99	99.2 ± .40
% Oxygen Saturation After Decompression Started and Before Aviox In Use	86	88	89	90	86	87.8 ± 1.60
% Oxygen Saturation, Lowest Values During Use of Aviox at Altitude	97	98	97	98	98	97.6 ± .49
Time From Decompression Initiated Until Aviox Was In Use (Seconds)	32	50	33	38	35	37.6 ± 6.53

It is noted that the times presented in Table 1 for the subjects to don and initiate the system in use may seem unduly long. This is attributed to the fact that for the first 15 seconds the subjects had to remain seated until the decompression was completed, and had to stand and walk 15 paces in place after the decompression.

DISCUSSION

It was originally thought that the degree of hypoxia associated with breathing ambient air at 10,000 feet (arterial oxygen saturation levels of 87%) was such that no great impairment would occur. However, more recent work has suggested that this level is no longer acceptable for normal operations and that hypoxia is significant above 8,000 feet (arterial oxygen saturation levels of 93% breathing ambient air). Therefore, during normal operations, a 93% arterial oxygen saturation could be regarded as the acceptable lower limit for oxygen saturation in aircrew breathing an enriched oxygen supply at altitude.

It must be pointed out that this level of saturation for 8,000 feet is for sustained routine operations. In an emergency situation, the arterial saturation associated with 10,000 feet is quite acceptable, and could even fall considerably lower than the values associated with breathing air between 8,000 and 10,000 feet for a short period of time. Recent work has shown that oxygen saturation levels of 65% were adequate to maintain mental alertness for short periods of time (three minutes) in subjects following exposure to altitudes of 80,000 feet. (Reference 5).

The results from this study indicate that the lowest oxygen saturation levels recorded in subjects using the Scott Aviox as a source of supplemental oxygen were well above critical levels for acceptable degrees of hypoxia during normal operations. Saturation levels were such as to be comparable with sea level values. Thus for the time at 22,000 feet, the system afforded more than the minimum protection required.

All subjects who participated in this evaluation found that the donning and initiating procedures were relatively simple. The unit came free of the retaining bracket with ease, actual opening of the unit, positioning the face mask and initiating oxygen flow was accomplished quickly and without any problem. The longest recorded time from start of decompression until the system was in use was 50 seconds. This was much longer than that required by the remaining four subjects and was attributed to an initial pause by the subject after the rapid decompression and before walking the required 15 paces. The remaining four times varied between 32 to 38 seconds which consisted of 15 seconds for the decompression plus the time to walk 15 paces, don and initiate the system. This would probably be the worst case encountered because crew members would generally be at their stations where they would have immediate access to the system. The time of useful consciousness at even a higher altitude such as 30,000 feet (approximately 60 seconds) as compared to 25,000 feet (approximately 120 seconds) is such that it would still allow crew members more than adequate time to implement the Aviox for use.

CONCLUSION

During these experiments, human subjects were exposed to hypobaric conditions which necessitated a need for supplemental oxygen. This was provided by the Scott Aviox Single Pak Emergency Oxygen supply. During use of this system, subjects were monitored to determine the degree of protection afforded by this system against hypoxia. At the altitudes used in this experiment, it was found that the system provided a more than adequate degree of protection against hypoxia. Although the altitudes used can be considered relatively low when compared to the upper operational limits of the LRPA and maximum flight altitudes of various jet aircraft, this system has been operationally tested at higher altitudes up to 40,000 feet by the manufacturer. The United States Federal Aviation Administration (FAA) have also approved this system for use in various aircraft such as the 707, 727, 737, 747, L1011 and the DC10. Based on these facts, and the system's observed performance at the experimental altitudes, this should be regarded as an adequate means of supplying supplemental oxygen to crew members in the new Long Range Patrol Aircraft, the CP 140.

REFERENCES

1. Aerospace Medicine, 2nd Edition. Edited by W.H. Randel (1971) Baltimore: Williams & Wilkins, Chapter 14.

2. Aviation Medicine, Physiological and Human Factors, Volume I. Edited by J. Ernsting (1978) London Tri-Med Books Ltd. Chapters 3 - 5.

3. Ernsting, J. Prevention of Hypoxia - Acceptable Compromise. Aviation Space Med - Page 495 to 502, Volume 49 No. 3. March 1978.

4. Manningham, D. Oxygen Roullette, Business and Commercial Aviation Magazine. March 1975.

5. Porlier, J.A.G., M. Paul, G.R. Wright and K.N. Ackles. Study of the Affects of Hypoxia and Pressure Breathing on the Ability to Fly a Simulated Emergency Descent. Preprint 1980 Aeromedical Scientific Meeting, Aerospace Medical Association.

PHOTOGRAPH NO. 1

SCOTT AVIOX EMERGENCY OXYGEN SYSTEM SHOWN IN NORMAL
STORAGE CONFIGUREMENT WITH REPLACEMENT SOLID STATE OXYGEN GENERATOR

PHOTOGRAPH NO. 2

T AVIOX EMERGENCY OXYGEN SYSTEM SHOWN IN
OPEN POSITION READY FOR USE